

CLAIMS

1. Pressure sensor (1, 13), able to operate at high temperature and to measure the pressure of a hostile medium, characterized in that it comprises:

5 - a sensing element (4) integrating a membrane (8) in monocrystalline silicon carbide and made by micro-machining a substrate in polycrystalline silicon carbide, a first surface of the membrane being intended to be in contact with said medium, a second surface of
10 the membrane comprising detection means (9) to detect membrane deformation and connected to electric contacts (10) to connect electric connection means (11, 17), the surfaces of the sensing element (4) intended to be in contact with the said medium being chemically inert
15 relative to this medium;

 - a carrier (5, 15) for the sensing element (4) supporting the sensing element so that said first surface of the membrane (8) may be placed in contact with said medium and said second surface of the
20 membrane (8) may be shielded from contact with said medium, the carrier (5, 15) being in polycrystalline silicon carbide;

 - a seal strip (6), in material containing silicon carbide, brazed between the carrier (5, 15) and
25 the sensing element (4) to shield the second surface of the membrane (8) from any contact with said medium.

2. Pressure sensor according to claim 1, characterized in that sensor (13) being intended to

measure absolute pressure, the carrier (15) comprises a sealed closing part (14) so that a vacuum may be set up inside the carrier.

3. Pressure sensor according to either of claims 1 or 2, characterized in that the carrier (5, 15) is tube-shaped, the sensing element (4) closes one of the tube ends, the first surface of the membrane (8) being directed towards the outside of the tube.

10 4. Pressure sensor according to claim 3, characterized in that the carrier (5, 15) comprises a thread so that it can be screwed to a reservoir (2) containing the medium.

15 5. Pressure sensor according to any of claims 1 to 4, characterized in that an insulating interface layer is provided between the membrane (8) and the substrate part of the sensing element (4).

20 6. Pressure sensor according to claim 5, characterized in that the insulating interface layer is in a material chosen from among silicon oxide, silicon nitride and carbon-containing silicon.

25 7. Pressure sensor according to any of claims 1 to 6, characterized in that said electric contacts (10) are in a silicide containing tungsten.

30 8. Pressure sensor according to any of claims 1 to 7, characterized in that the connection between the

electric contacts (10) and the electric connection means (17) is obtained with a solder material (18) which withstands high temperatures.

5 9. Pressure sensor according to claim 8, characterized in that said solder material (18) is a silicide containing tungsten.

10 10. Pressure sensor according to any of claims 1 to 7, characterized in that conductor means (11) are provided, forming a spring to ensure the connection between the electric contacts (10) and the electric connection means.

15 11. Pressure sensor according to any of claims 1 to 10, characterized in that said detection means (9) comprise at least two piezoresistive gauges.

20 12. Pressure sensor according to claim 11, characterized in that said piezoresistive gauges are in monocrystalline silicon carbide.

25 13. Manufacturing method by micro-machining at least one membrane sensing element for a pressure sensor able to operate at high temperature and to measure the pressure of a hostile medium, comprising the following steps:

30 a) producing a layer (25) of monocrystalline silicon carbide on one surface of a substrate (20) containing polycrystalline silicon carbide,

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b) fabricating, on the free surface of layer
(25) of monocrystalline silicon carbide, detection
means (26) to detect membrane deformation,

c) fabricating electric contacts (27) on said
5 free surface to connect the detection means (26) to
electric connection means,

d) forming the membrane (28) of said sensing
element by removal of matter from the other surface of
the substrate (20), so as only to preserve
10 polycrystalline silicon carbide.

14. Method according to claim 13, characterized
in that the fabrication of said layer (25) of
monocrystalline silicon carbide comprises:

15 - the transfer of a first layer of
monocrystalline silicon carbide to said surface of the
substrate (20),

- depositing by epitaxy a second layer (24) of
monocrystalline silicon carbide on the first layer (23)
20 in order to obtain said layer (25) of monocrystalline
silicon carbide of controlled thickness.

15. Method according to claim 13, characterized in that
the fabrication of said layer of monocrystalline silicon carbide
25 comprises the use of a wafer in monocrystalline silicon carbide
in which a layer has been defined by a layer of microcavities
generated by ion implantation, said wafer being bonded to said
surface of substrate (20) then cleaved at the layer of
microcavities so as only to preserve said layer defined on the
30 substrate.

16. Method according to claim 15, characterized
in that cleavage of the wafer is obtained by
coalescence of the microcavities resulting from a heat
5 treatment.

17. Method according to either of claims 15 or
16, characterized in that the bonding of said wafer to
substrate (20) is obtained by molecular bonding.

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18. Method according to any of claims 13 to 17,
characterized in that, before the step to produce said
layer of monocrystalline silicon carbide (25), an
insulating interface layer (21) is deposited on
15 surface (22) of substrate (20) on which said layer (25)
is to be produced.

19. Method according to any of claims 13 to 18,
characterized in that, during the membrane (28)
20 formation step, the removal of matter from the other
surface of the substrate is conducted using an
operation chosen from among mechanical polishing and
chemical etching.

25 20. Method according to claim 13, characterized
in that, before step a) the method comprises the
following preliminary steps:

- machining a substrate (30) to obtain a bump
(31) of complementary shape to the shape of the

desired sensing element as seen from the hostile medium side,

- depositing a layer (32) in polycrystalline silicon carbide on substrate (30) on the bumping (31) side,

- levelling layer (32) previously deposited down as far as the tip of the bump (31), steps a) and d) then being conducted in the following manner:

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a) the layer (35) of monocrystalline silicon carbide is formed on the substrate on the side of the levelled layer,

d) the membrane (38) of said sensing element is formed by removing the initial substrate.

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21. Method according to claim 20, characterized in that said substrate (30) is in silicon.

20 22. Method according to either of claims 20 or 21, characterized in that the fabrication of said layer (35) in monocrystalline silicon carbide comprises:

- the transfer of a first layer (33) of monocrystalline silicon carbide to the substrate,

25 - depositing by epitaxy a second layer (34) of monocrystalline silicon carbide on the first layer (33) of monocrystalline silicon carbide in order to obtain said monocrystalline silicon carbide layer (35) of controlled thickness.

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23. Method according to any of claims 20 to 22, characterized in that the levelling step is made by mechanical-chemical polishing.

5 24. Method according to either of claims 20 or
21, characterized in that the fabrication of said layer
(33) of monocrystalline silicon carbide comprises the
use of a wafer in monocrystalline silicon carbide in
which a layer has been defined by a layer of
10 microcavities generated by ion implantation, said wafer
being bonded to substrate (30) on the side of the
levelled layer then cleaved at the layer of
microcavities so as only to preserve said defined layer
on the substrate.

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25. Method according to claim 24, characterized
in that cleavage of the wafer is obtained by
coalescence of the microcavities resulting from a heat
treatment.

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26. Method according to either of claims 24 or
25, characterized in that the bonding of said wafer to
the substrate is obtained by molecular bonding.

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27. Method according to any of claims 20 to 26,
characterized in that, before the step to produce said
layer of monocrystalline silicon carbide (35), an
insulating interface layer is deposited on the surface
of the substrate on which said layer is to be made.

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28. Method according to any of claims 20 to 27, characterized in that removal of the initial substrate (30) is obtained by chemical etching.

5 29. Method according to claim 13, characterized in that before step a) the method comprises the following preliminary steps:

 - machining a substrate (40) to obtain a bump (41) of complementary shape to the shape of the desired
10 sensing element as seen from the hostile medium side,

 - depositing a layer (42) of polycrystalline silicon carbide on substrate (40) on the side of the bump (41),

 - levelling the layer (42) deposited previously
15 until only the desired thickness of membrane subsists above the bump (41),

steps a) and d) then being conducted in the following manner:

 a) the layer of monocrystalline silicon carbide
20 is formed on said levelled layer,

 d) the membrane (48) of said sensing element is formed by removal of the initial substrate.

30 30. Method according to claim 29, characterized in that said substrate (40) is in silicon.

 31. Method according to either of claims 29 or 30, characterized in that the levelling step is made by mechanical-chemical polishing.

32. Method according to any of claims 29 to 31,
characterized in that the fabrication of said layer of
monocrystalline silicon carbide is obtained using a
wafer of monocrystalline silicon carbide in which said
5 layer has been defined by a layer of microcavities
generated by ion implantation, said wafer being bonded
to this substrate on the side of the levelled layer
then cleaved at the layer of microcavities so as only
to preserve the layer of monocrystalline silicon
10 carbide on the substrate.

33. Method according to claim 32, characterized
in that cleavage of the wafer is obtained by
coalescence of the microcavities resulting from a heat
15 treatment.

34. Method according to either of claims 32 or
33, characterized in that the bonding of said wafer to
the substrate is obtained by molecular bonding.
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35. Method according to any of claims 29 to 34,
characterized in that removal of the initial substrate
is obtained by chemical etching.

25 36. Method according to any of claims 29 to 35,
characterized in that an insulating interface layer
(43) is deposited on the levelled layer before the
layer of monocrystalline silicon carbide.

37. Method according to any of claims 29 to 36, characterized in that, during the formation of detection means (44), the remaining part of the monocrystalline silicon carbide layer is removed.

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38. Method according to any of claims 13 to 37, characterized in that, the method being a collective manufacturing method for producing sensing elements from one same substrate (40), a final substrate cutting
10 step is provided to obtain separate sensing elements.